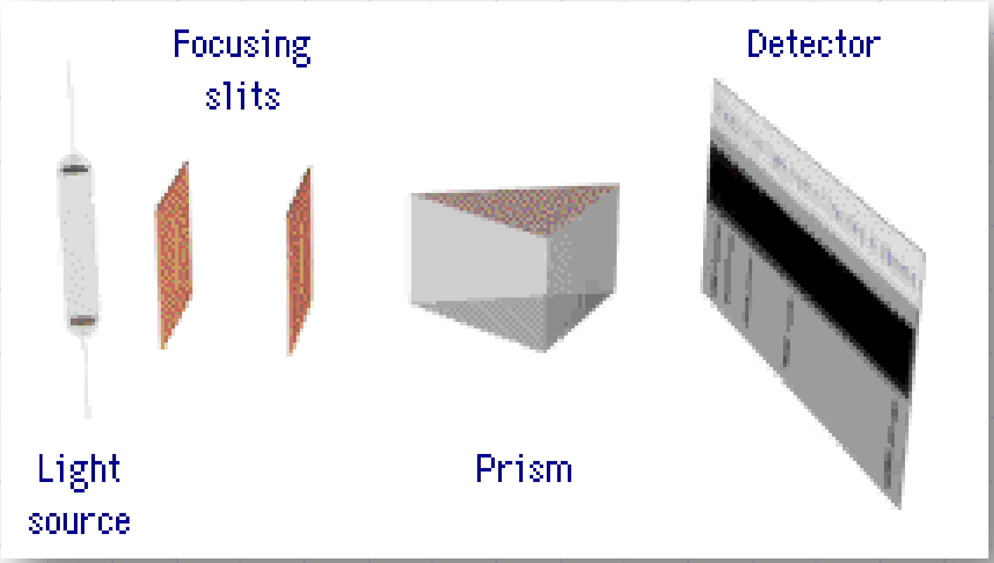
Atomic Emission Spectra

Adapted from Scheffler
Lincoln HS, Portland OR

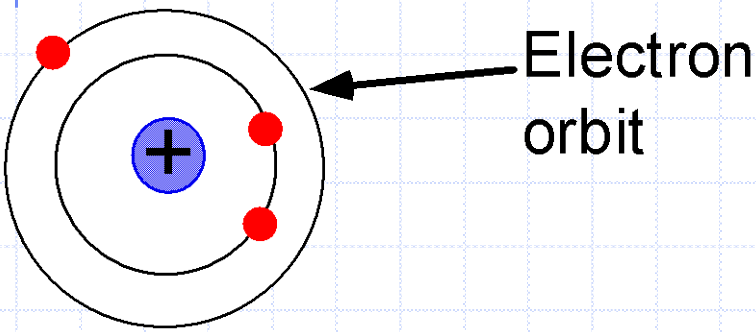
Line Emission Spectra of Excited Atoms

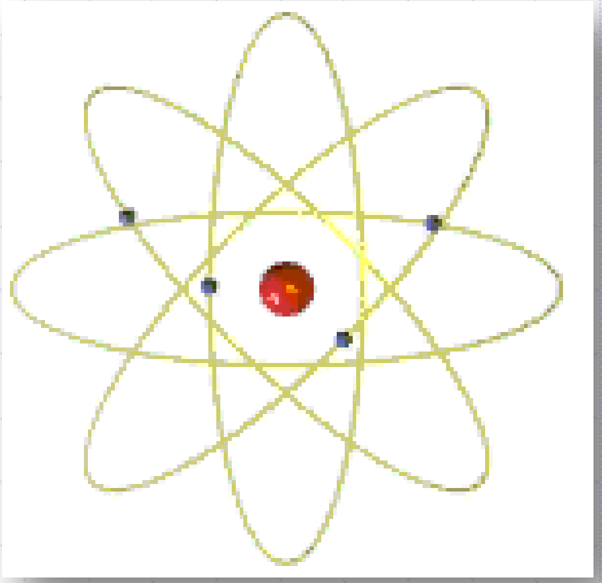
- Excited atoms emit light of only certain wavelengths
- The wavelengths of emitted light depend on the element.



Atomic Spectra

One view of atomic structure in early 20th century was that an electron (e-) traveled about the nucleus in an orbit.

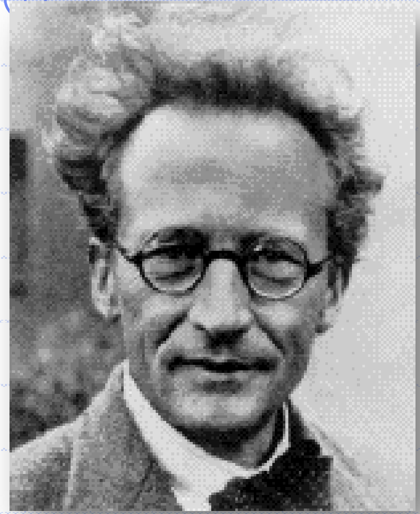




Atomic Spectra and Bohr

- Bohr said classical view is wrong.
- Need a new theory — now called QUANTUM or WAVE MECHANICS.
- e- can only exist in certain discrete orbits
- e- is restricted to QUANTIZED energy state (quanta = bundles of energy)

Quantum or Wave Mechanics



E. Schrodinger 1887-1961

- Schrodinger applied idea of e- behaving as a wave to the problem of electrons in atoms.
- He developed the WAVE EQUATION
- Solution gives set of math expressions called WAVE FUNCTIONS, Ψ
- Each describes an allowed energy state of an e-

Heisenberg Uncertainty Principle

W. Heisenberg 1901-1976

- The problem of defining nature of electrons in atoms solved by W. Heisenberg.
- He observed that one cannot simultaneously define the position and momentum (= m•v) of an electron.
- If we define the energy exactly of an electron precisely we must accept limitation that we do not know exact position.

Atomic Line Emission Spectra and Niels Bohr

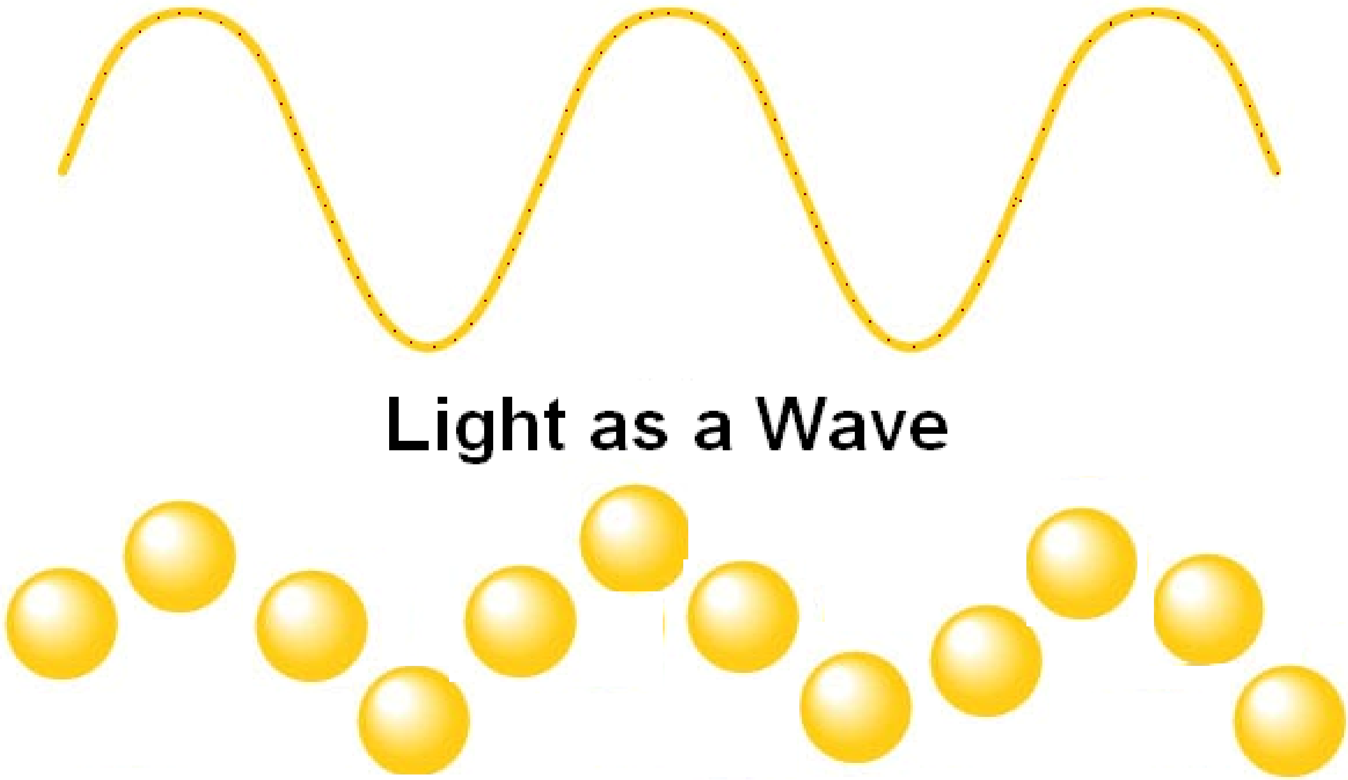
Niels Bohr

(1885-1962)

Bohr's greatest contribution to science was in building a simple model of the atom. It was based on an understanding of the LINE EMISSION SPECTRA of excited atoms.

- Problem is that the model only works for H

Electromagnetic radiation.

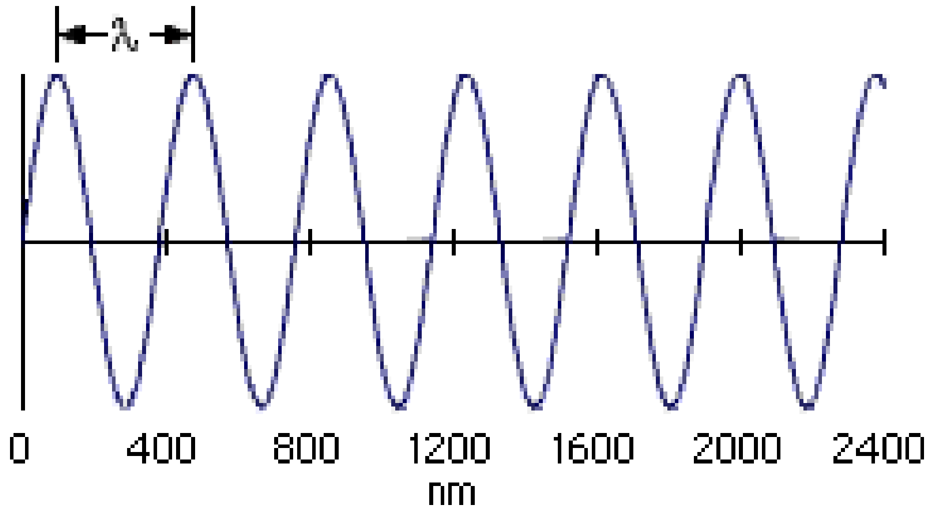


Light as a Wave

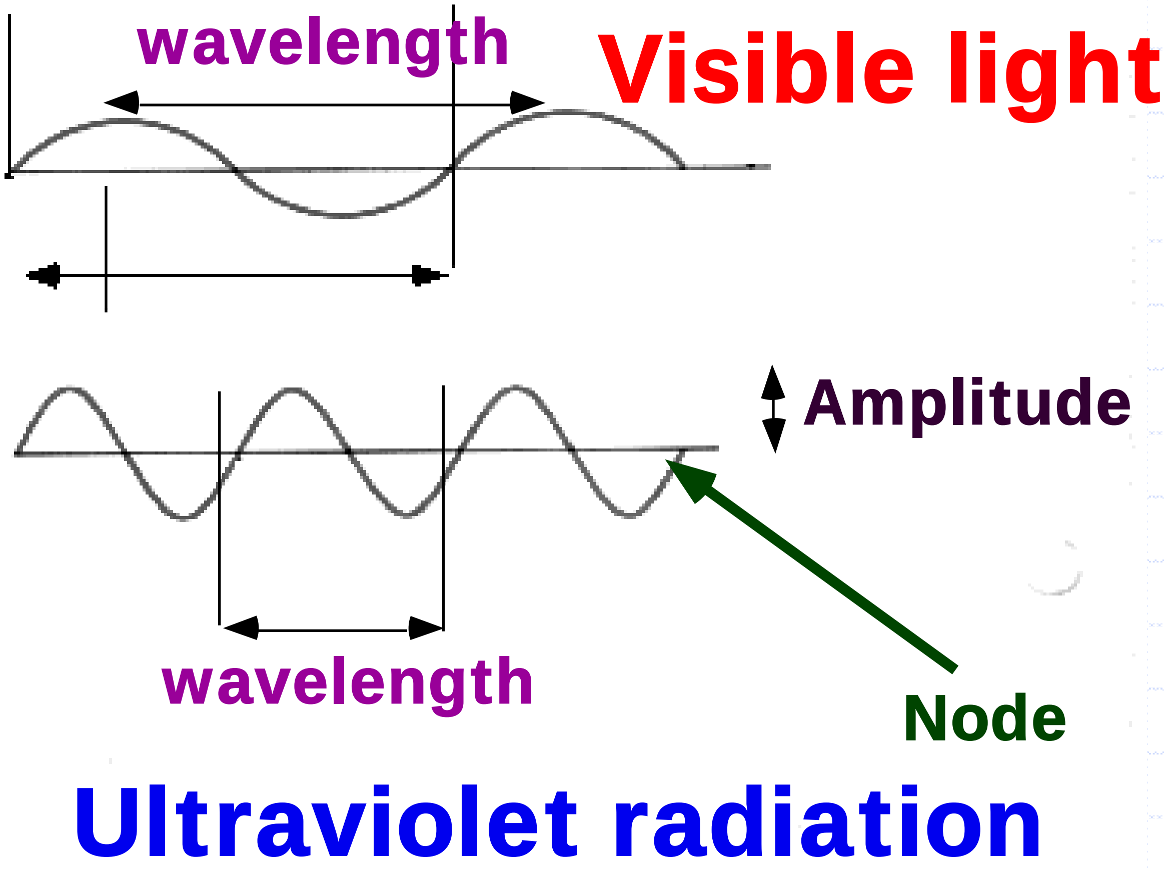
Light as a stream of photons (Packets of energy)

Electromagnetic radiation.

- Most subatomic particles behave as PARTICLES and obey the physics of waves.



Electromagnetic radiation.



Electromagnetic radiation.

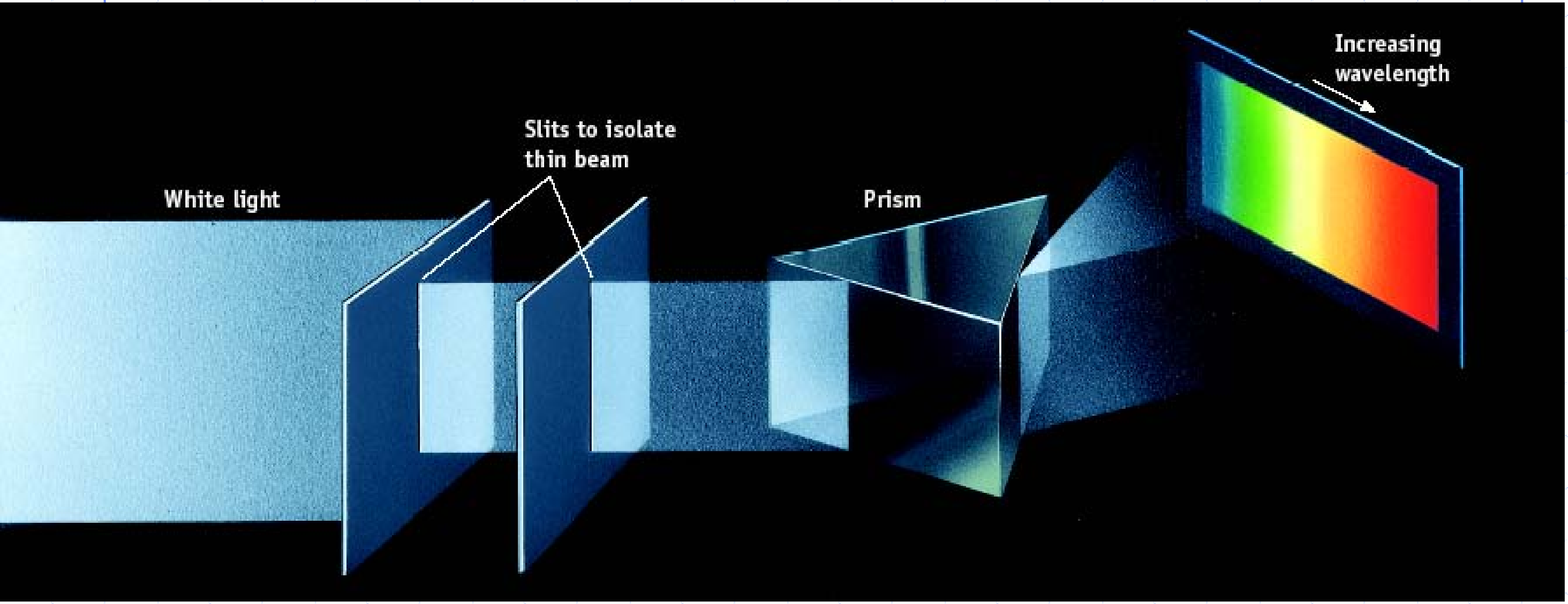
- Waves have a frequency
- Use the Greek letter "nu", ν, for frequency, and units are "cycles per sec"
- All radiation: $\lambda \cdot \nu = c$

  where c = velocity of light = 3.00×10^8 m/sec, λ = wavelength, ν = frequency

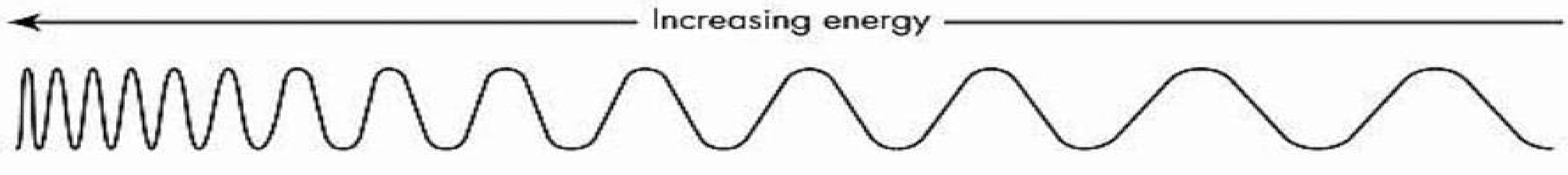
Long wavelength --> small frequency

Short wavelength --> high frequency

Spectrum of White Light



Electromagnetic Spectrum



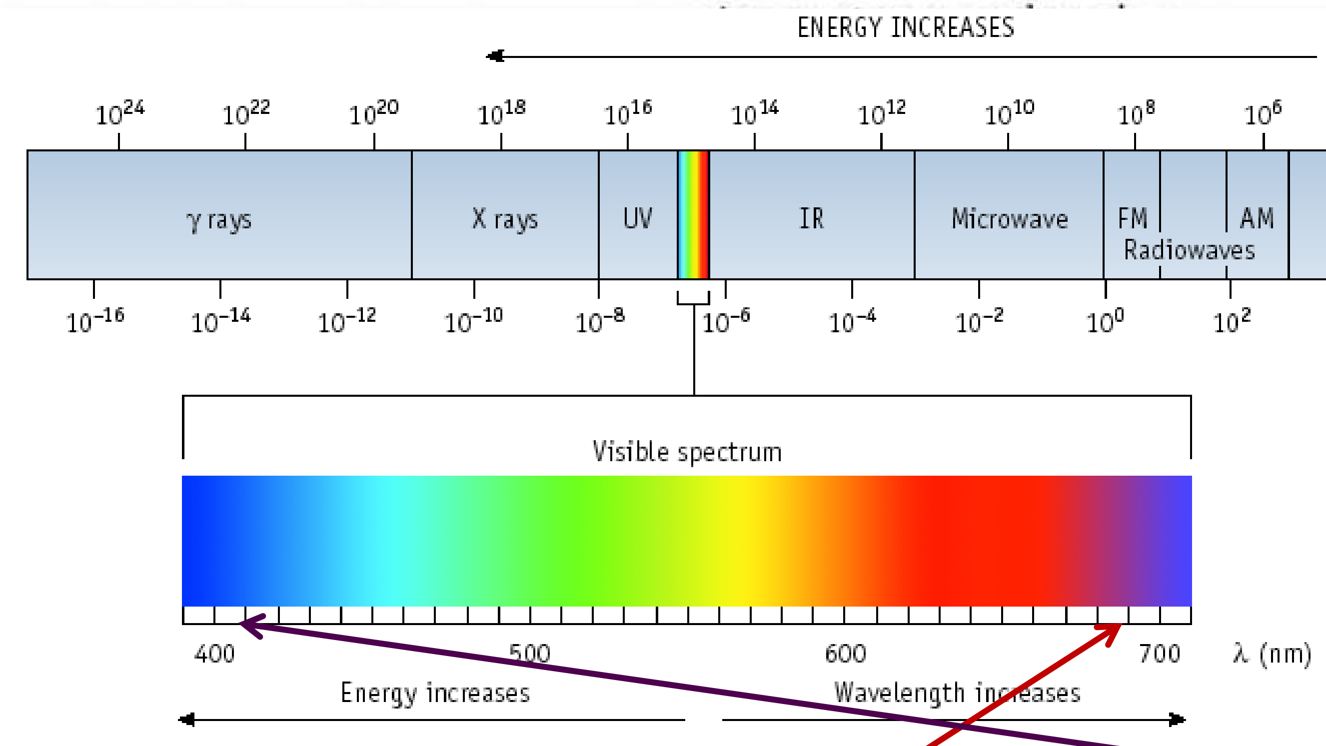


Figure 7.3 The electromagnetic spectrum. Visible light (enlarged portion) is a very small part of the entire spectrum. The radiation's energy increases from the radio-wave end of the spectrum (low frequency, ν, and long wavelength, λ) to the γ-ray end (high frequency and short wavelength) [CD-ROM, Screen 7.4].

In increasing energy, ROY G BIV

High frequency	lower frequency
Short wavelength	longer wavelength
High energy	lower energy

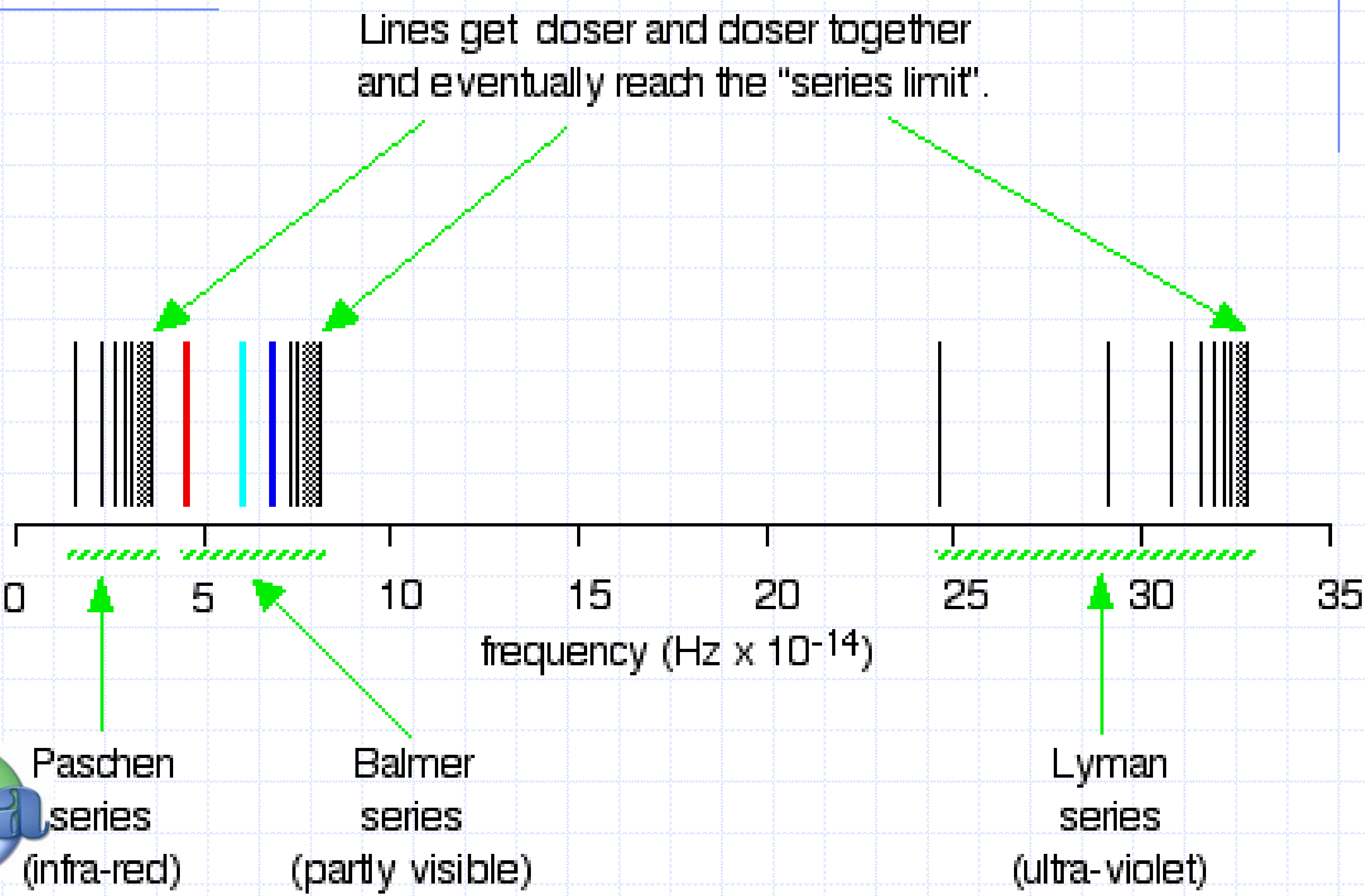
Emission of Light

- When electrons are excited they can move to a higher energy level.
- When they move back down they emit energy in the form of light
- The color of the light emitted depends on the FREQUENCY
- This light forms a LINE SPECTRUM

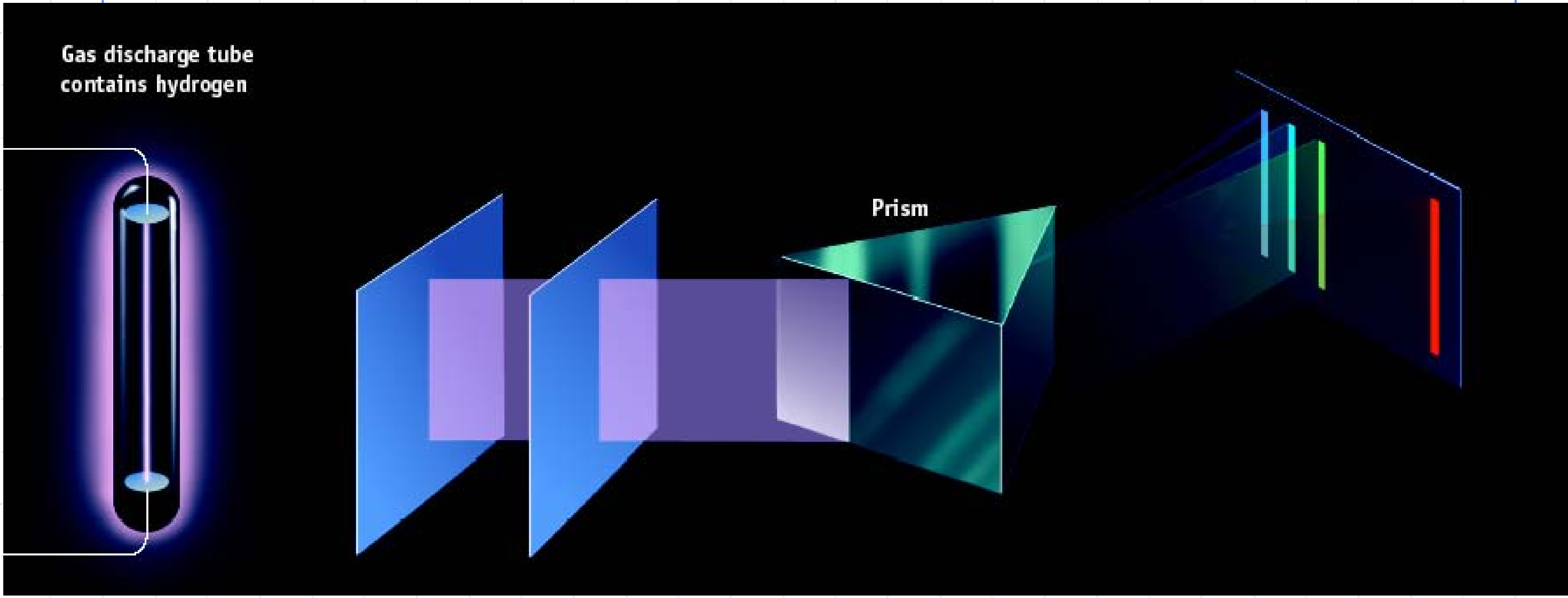
Line Spectra

- Because electrons can only exist in certain energy levels, only certain transitions can occur.
- e.g. an electron can move from the second energy level (n=2) to the first energy level (n=1).
- Each transition emits light of a particular frequency.
- Therefore a line spectrum is produced.
- A continuous spectrum would suggest that electrons can exist anywhere around the nucleus

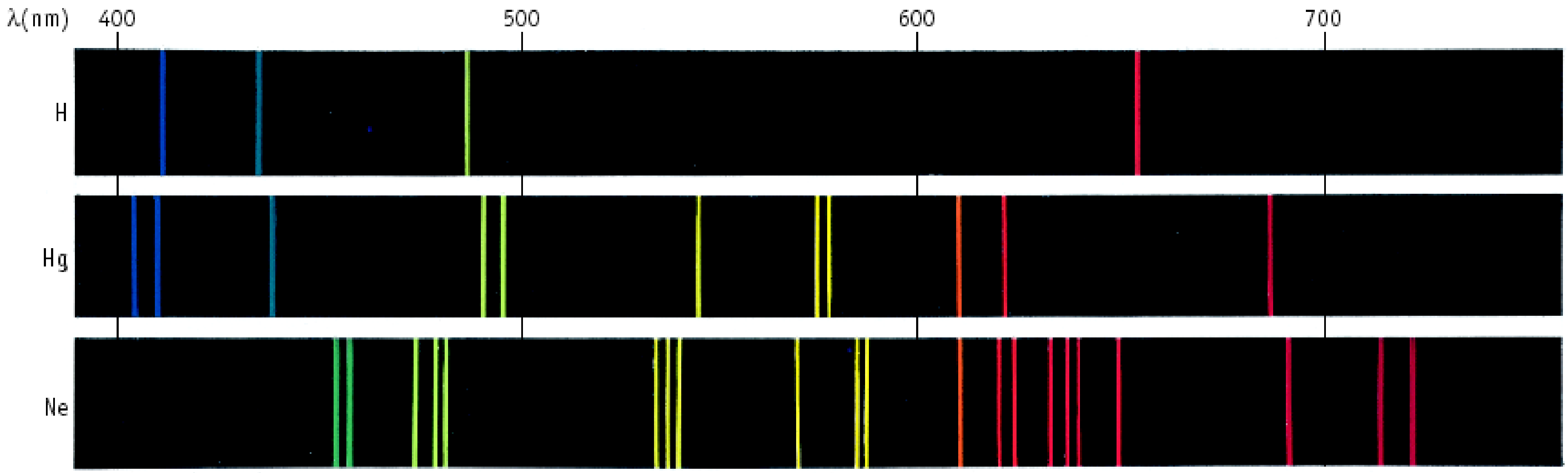
Hydrogen Emission Spectrum



Spectrum of Excited Hydrogen Gas

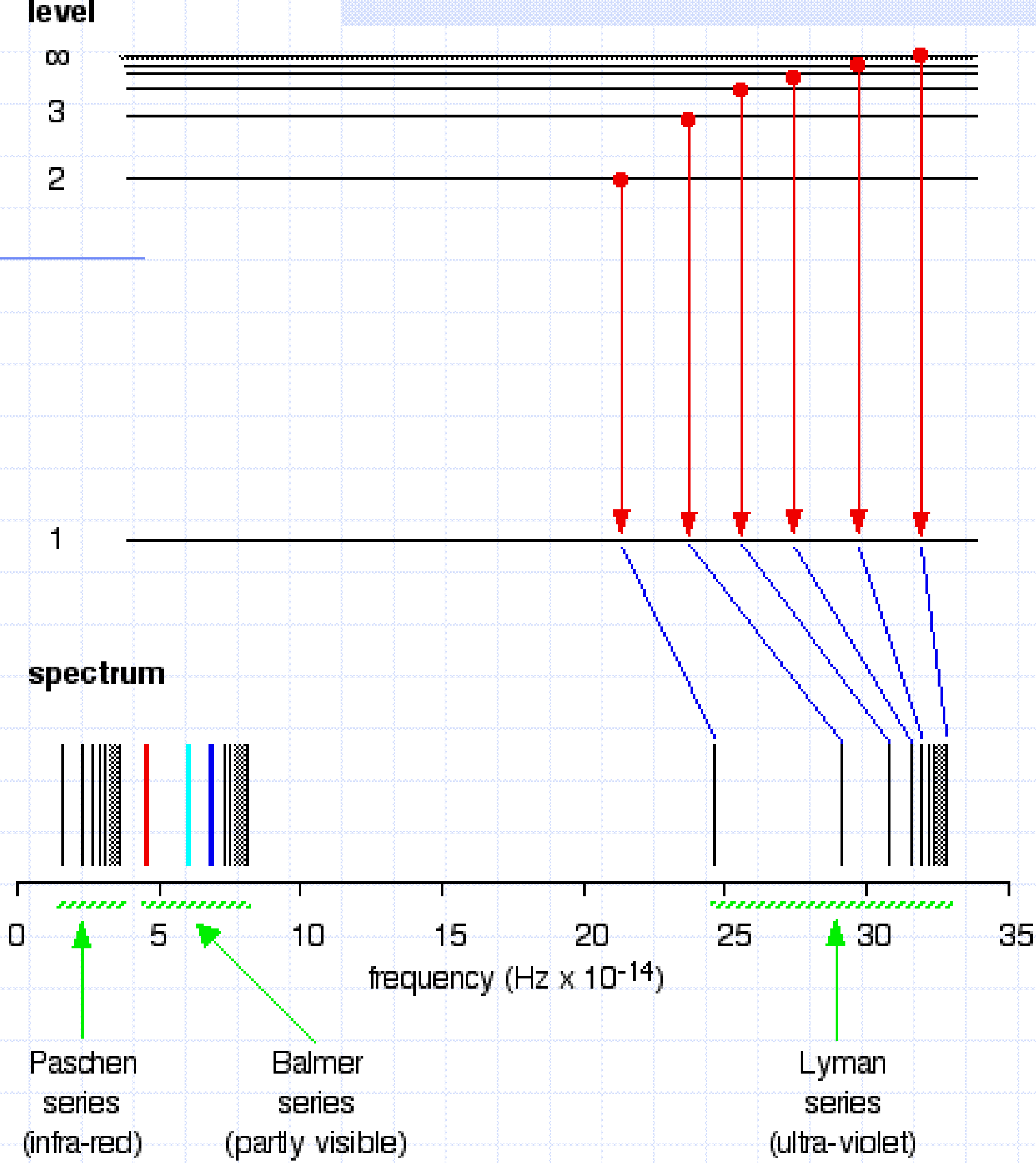


Line Spectra of Other Elements



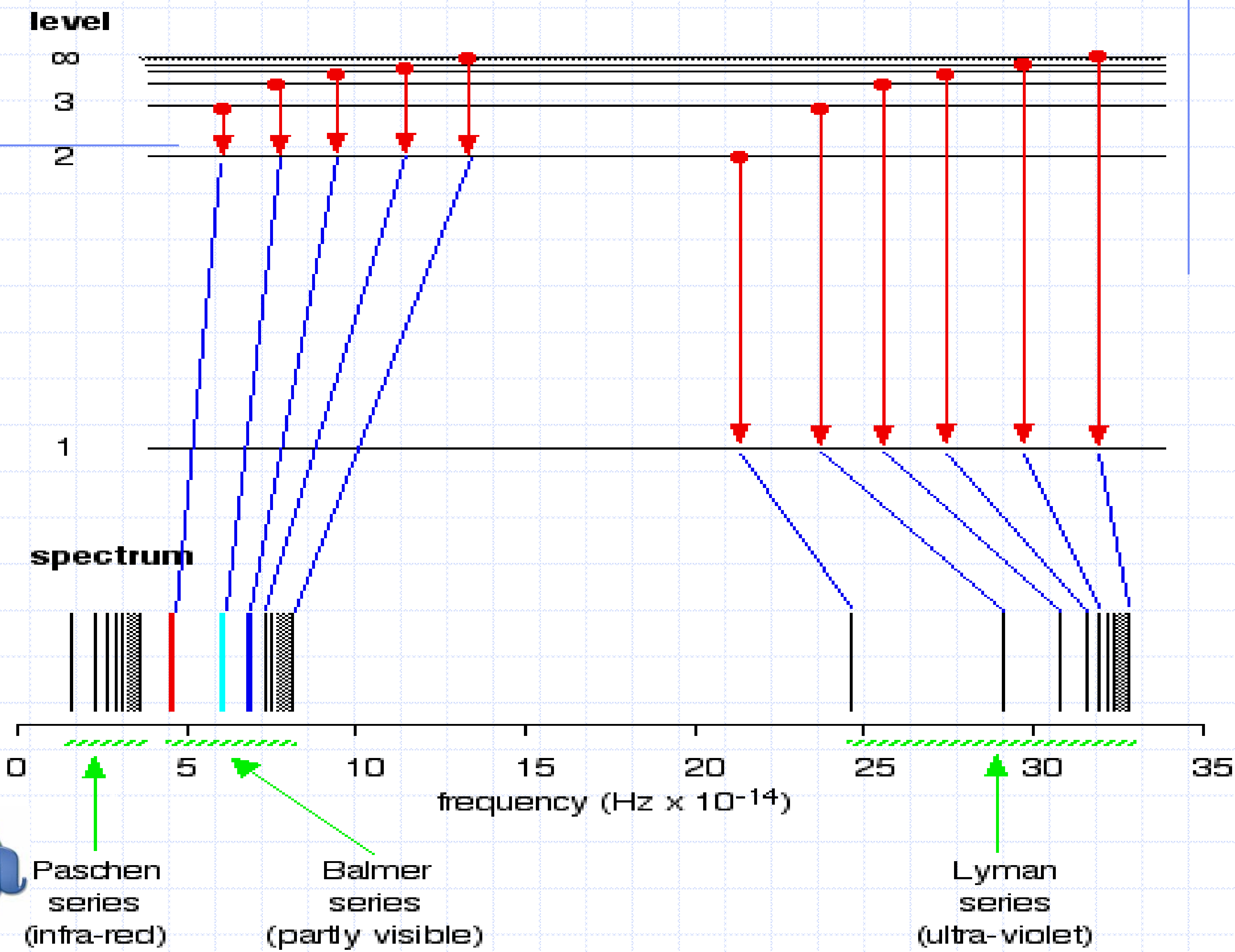
Which Frequencies can be observed?

- From n=x to n=1:
  - These are the transitions that emit the most energy (highest frequency or shortest wavelength), therefore in u.v. range.
  - N=3→ n=1 emits a higher frequency than n=2 → n=1 etc


level
∞
3
2
1
spectrum
0
5
10
15
20
25
30
35
frequency (Hz x 10-14)
Paschen series (infra-red)
Balmer series (partly visible)
Lyman series (ultra-violet)

Notes

- Notice that at higher frequencies the lines get closer together (converge)
- This indicates that the energy difference between levels becomes less as the level number increases.
- In other words: the difference in energy between n=1 and n=2 is greater than the difference in energy between n=2 and n=3



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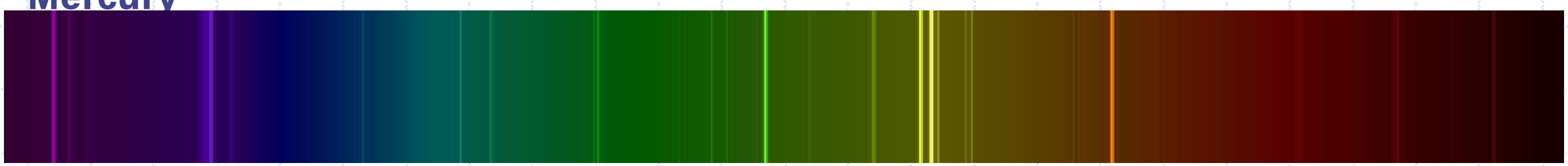
The lower energy part of the spectrum

- Represents lower energy transitions
- E.g. an electron moving from n=4 to n=3
- These energy levels are closer so less energy is emitted.
- Convergence is also observed here, e.g lines for n=6 → n=3 will be extremely close to the line for n=7 → n=3
- Each series will come to an end with the line for the transition from n = ∞

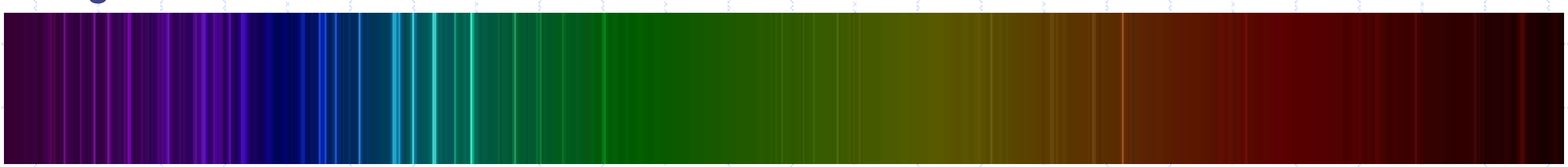
Some Atomic Emission Spectra

- **Hydrogen**

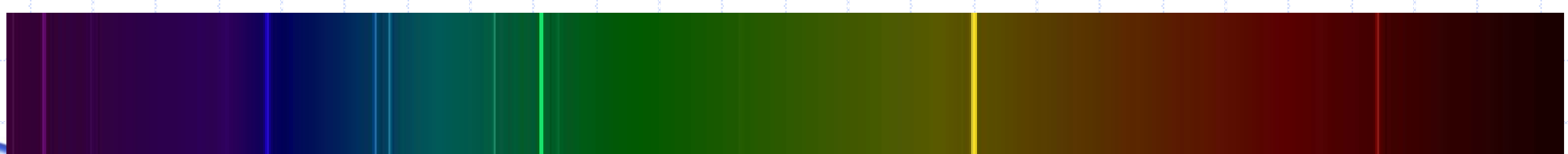
Mercury



Argon



Helium



Emission Spectrum Gizmo

- Go to http://www.explorelearning.com/
- You will need to sign in with your username and password which has already been created.
  - To find it, go to the "Resource Center" tab on our class wiki
- Once logged in, find the "Bohr Model of Hydrogen" gizmo in our class gizmos
- Use the learning guide which can be found in the assignment sheet under T02D03
- Complete the Gizmo for HW if not finished.